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Investigation on Abnormal Tissues Detection Methods for MRI Image

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Abstract

Magnetic resonance imaging (MRI) provides detailed information about the soft tissues of the brain to identify tumors, cancer or any abnormal conditions in brain.Usually these images contain a significant amount of noise caused by operators or some external factors.De-noising is essential before detection of any abnormal areas from these images. There are several de-noising methods. In this paper, wavelet denoising techniques are considered for denoising the MRI image. The quality of the image is assessed using Peak Signal to Noise Ratio (PSNR), Squared Error Mean (SEM) and Absolute Mean Error (AME). These de-noised images are very useful for the segmentation process to easily extract the abnormal area from the image.Segmentation plays a crucial role for detection of any abnormal areas, tumors and irregularities in brain images. For this process two unsupervised algorithms are proposed for the detection of abnormal area from de-noised image. Both Expectation Maximization and K-means segmentation algorithims are used to identify the abnormal tissues in a given MRI.The performance of both methods are analyzed with suitable parameters like Entropy, Area and Perimeter.These parameters show the performance of the algorithms for the segmentation process and hence a suitable algorithm can be applied.

Keywords: MRI image,PSNR,MSE,SEM,Entropy,Area,Perimeter.

1. INTRODUCTION

Bio-medical image processing techniques are used to take the information of human anatomy. Now a days in the field of medical there are several technogical developments occured in diagnosis systems out of them most commonly available images are X-ray,CT,MRI . These images give the information about hard and soft tissues of the body. This information is used to identify any abnormal cases, tumors, cancers etc. In this process MRI scan is very useful and it is harmless because there will be no radiation. This scan is based on magnetic field and radio waves, and it is more comfortable than other scans[2].These images provide detailed information about the abnormal areas, tumor type, position and size. For this reason, MRI imaging study is choosen for this work. These images correpted with some type of noise during tramission process. De-noising the image is very essential before detection of abnormal areas[6].This noise can be removed by using different filtering methods or some other techniques. In this paper different wavelet technique are used for de-noising the MRI. A wavelet is a "small wave", which has its

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energy concentrated in time to give a tool for the analysis of transient, non-stationary, or time-varying phenomena about analyzing signal with short duration finite energy functions[8,7]. There are two types of wavelet techniques continuous wavelet transforms and discreate wavelet transforms.There several types of DWT, out of them db2, bior3.3 and sym6 are considered here. By using these wavelets MRI image can be de-noised.This de-noised images helps the segmentation process to easily extract the abnormal areas form the image.

In digital image processing different segmentation methods are used for the subtraction of the region of interests from the images.Segmentation plays vital role in medical image processing, where clustering technique widely used in medical application particularly for brain tumor detection in magnetic resonance imaging (MRI)[9, 10]. In this paper considering two unsupervised algorithms, Expectation maximization (EM) and K-means method has been taken in to consideration, both algorithms are used to find the natural clustres with in given data base[4].These two clustering methods can be based on pixel intensity, texture or some combination of these[5]. This paper MRI abnormal image is considered and above mention segmentation methods are developed to extract abnormal area from the back ground.The parameters area, perimeter, entropry are calculated on both segmentation methods, based on these parameters performance of the algorithm are analysed.

2. Proposed Methods

2.1 K-means algorithm

K-means is the clustring approach method.Clustring is the method of dividing set of data points. Each cluster can be characterized by single reference point. The variance is used in clustring it's indicate the quality of partitioning and the error is measired sum of all variance is given by.

$$D = \sum_{i=1}^{k} \sum_{j=1}^{m_i} \left\| x_{ij} - r_i \right\|^2 \qquad (1)$$

Where x_{ij} is the j[th] point of the i[th] cluster, r_i is the reference point of the i[th] cluster and m_i is the no of points in the cluster. $\left\| x_{ij} - r_i \right\|$ indicates the distance between the x_{ij} and r_i.Error indicates the over all spread points about the reference point and its value should be small as possible[1,5].In this cluster N no of clusters, partition can be consired as $L=(L_1, L_2.., L_k)$for a given points and corresponding centers are $C = (C_1, C_2 ..., C_k)$.The assigment of cluster is keep repeating untill the point assisment stabilises that is no more rearrangement of points are left[1].

1. Initially intensity mean value of the each region is defined
2. Determine the number of clusters and set it as N
3. The number of patterns is selected as N corresponding to N centried for N clusters.
4. Compute the new centroid classifies each pattern to the closest cluster centroid.
5. This process is reperted untill the desired result is achieved.

2.2 Expectation Maximization algorithm

This is unsuperwised algorithm it is used to find the estemated parameters of maximum likehood or posterior probability. When the data are incomplete are missing.This method provides a systematic approach to find the maximum likehood modal[3]. The EM algorithm is parameterizing based on classes, while at the same time determining parameters describe the bias field[4]. With an iteration of the EM algorithm, the mixture model parameters and the bias field parameters are updated and perform the classification. In this method parameter eatimation into two steps first Estep calculate that is expected value and second step Mstep computes the parameters for maximizing value based on E value.First step i.e E step eatemation of parameter vector φ_0 is initially estimated[4,5.] The posterior probability which determines the class of the voxel is given by.

$$p\left(y_i \middle| \gamma_i = j, \theta_j\right) = G_{\sigma j}\left(y_i - \mu_j\right) \qquad (2)$$

Where $G_{\sigma j}$ is Gaussian modeling class j, γ_i is class of i[th] voxel, μ_j is mean intensity of the j[th] class,$\sigma_j$is standard deviation of the j[th] class

$$p\left(\gamma_i = j y_{i,\theta}\right) = \frac{p\left(y_i \middle| \gamma_i = j, \theta_j\right) p\left(\gamma_i = j\right)}{\sum_j p\left(y_i \middle| \gamma_i = j, \theta_j\right) p\left(\gamma_i = j\right)} \quad (3)$$

y_i is the intensity value of voxel i of the j^{th} class,γ_i represents the estimated distribution is given by θ.

Maximization step

$$\mu_j = \frac{\sum_i y_i p\left(\gamma_i = j y_{i,\theta}\right)}{\sum_i p\left(\gamma_i = j y_{i,\theta}\right)} \quad (4)$$

$$\sigma_j^2 = \frac{\sum_i p\left(\gamma_i = j \middle| y_{i,\theta}\right)\left(y_i - \mu_j\right)^2}{\sum_i p\left(\gamma_i = j y_{i,\theta}\right)} \quad (5)$$

The expectation step and maximization step described above are iterated until the desiredresult is achieved

1. Initially the image consists of N no of classes.
2. Based on number of classes φ_0 is estimated.
3. E-step is computed based on this estimated perameter M is excuted until it convergence.
4. The E-step computes the class probability of each pixel. At each iteration based on the current estimation of φ(s).
5. The new expectation of φ(s+1) is determined in M-step, based on values of E-step.
6. The maximum estimator of φ is produced after convergence
7. To generate the classification matrix C.

2. Preformance parameters

After de-noising the image parameters PSNR, SEM and AME assessed quality of the image. The quality of image is good when high PSNR and low SEM and low AME.In segmentation process to extract the abnormal area from the image.The parameters Entropy, Area and Perimeter shows the performance of the algorithims.

- Peak Signal to Noise Ratio (PSNR): Peak Signal to Noise Ratio is ratio between maximum possible power of original image and the power of corrupted noise. The small value of Peak Signal to Noise Ratio (PSNR) means that image is poor quality.

$$\text{PSNR} = 20\log_{10}\left(\frac{\max_I}{\sqrt{\text{SEM}}}\right) \quad (6)$$

Where max_I is a maximum possible pixel value.

- Squared Error Mean (SEM): Square Error Mean (SEM) is the sum of all squared value difference divided by image size it's measure between the original image and reconstructed image.The large value of MSE means that image is poor.

$$\text{SEM} = \frac{1}{KL}\sum_{i=1}^{K}\sum_{j=1}^{L}\left(p(i,j) - q(i,j)\right)^2 \quad (7)$$

- Absolute Mean Error (AME): Absolute Mean Error (AME) gives the absolute error between two images. The large value of AME means that image is poor quality.

$$\text{AME} = \frac{1}{KL}\sum_{i=1}^{K}\sum_{j=1}^{L}\left|\left(p(i,j) - q(i,j)\right)\right| \quad (8)$$

- Entropy

Entropy measures the average missing imformation on a ramdom source.

$$H(x) = \sum_{x \in X} p_x(X) \log p_x(X) \quad (9)$$

Where H is the measure of uncertainty in entropy, X is the observed area, x is the intensity value and p(X) is probability of image.

- Perimeter

Perimeter calculated the shape of the object or image is calculated as no of pixels transvered around the boundryof the object.

$$P_b = \sum_{i=1}^{N-1} |x_i - x_{i+1}| \quad (10)$$

P_b is the perimeter of the shape

- Area

Area estimates the objects in binary image. Whose value corresponds roughly to the total number of on pixels in the observed area.

$$Size = \left(\left(\sqrt{p}\right) * 0.264\right) mm^2 \quad (11)$$

Where P is no of white pixels in the tumour region

4. Results

The paper focuses on detection of abnormal areas form the de-noised MRI image. For this process two algorithms namely K-means and Expectation Maximization methods are proposed. These methods are generated on the image. The observed segmented area in both methods is observed below.The paremeters Entropy, Area and Perimeter gives the cahracterisitcs of the estimated area.

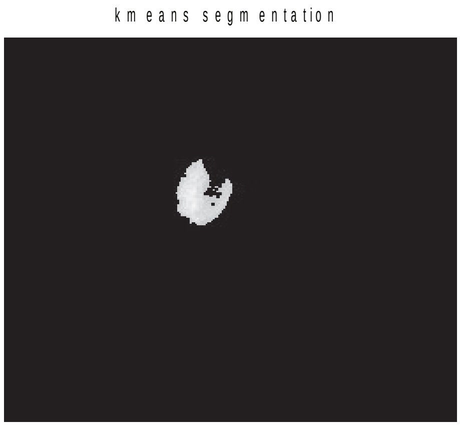

Fig.1.K-means Segmentation

Fig.2.Expectation Maximization Segmentation

Table.1 Performance Parameters on MRI

Parameters	db2		bior3.3		sym6	
	k-means	EM	k-means	EM	k-means	EM
SEM	0.0561	8.9050	0.0561	3.3972	0.0561	5.8775
PSNR	60.6406	38.6345	60.6411	42.8195	60.6400	40.4389
AME	$2.6521e^{-006}$	$2.9699e^{-005}$	$2.6515e^{-006}$	$1.9292e^{-005}$	$2.6516e^{-006}$	$2.4748e^{-005}$
Entropy	0.1141	0.1141	0.1141	0.1141	0.1141	0.1141
Area	810.7500	$1.0076e^{+003}$	810.7500	$1.0078e^{+003}$	810.7500	$1.0076e^{+003}$
Perimeter	170.0244	147.6396	170.0244	147.6396	170.0244	147.6396

From the above table it is observed that various wavelet techniques are used for de-noising the MRI. The quality parameters are computed and their values are compared for the three wavelets db2, bior3.3 and sym6. The bior3.3 wavelet provides better quality of image, with high PSNR, low SEM and low AME values when compared to other wavelets.In segmentation process the method Expectation Maximization provide the good results when compared with K-means.The parameters entropy, area, perimeter of the abnormal area is more in EM method.

Conclusions

In this paper Expectation Maximization and K-means algorithms implemented for detection of abnormal ares of MRI brain image. Before detection of abnormal area image is de-noised by using db2, bior3.3 and sym6 wavelet techniques. The wavelet bior3.3 provides good quality image, it has high PSNR low SEM and low AME when compared to db2 and sym6.This de-noised image is used for the segmentation process. The K-means and Expectaion Maximization segmentations are the proposed algorithms. Both methods can be used to find natural clusters within given MRI. EM method provides the accurate results when compared to K-means method.The comparative parameters Entropy, Area, Perimeter are more in EM where as in K-means these parameters are less. The obtaied abnormal area from EM is $1.0076e^{+003}$ where as in k-means this value is less i.e 810.7500.

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